

***Blackstrap Lake Water Quality Report
2008***

Prepared for
The Blackstrap Watershed Stewards

Monitoring and Assessment Branch
Stewardship Division
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1.0 Introduction and Background

1.1 General Description, Geography and Hydrogeology of Blackstrap Reservoir

Blackstrap Reservoir (Lake) was created in 1967 as part of the Saskatoon-Southeast Water Supply (SSWS) system, which included five other reservoirs, and approximately 190 km of canal. Water from Lake Diefenbaker is pumped through the canals and reservoirs for the purpose of irrigation, recreation, maintaining wildlife habitat and industry (e.g. potash).

Blackstrap Reservoir is 14.5 km long, 0.8 km wide and located approximately 47 km southeast of Saskatoon, Saskatchewan. The lake's surface area is approximately 12 km² and its maximum depth is approximately 9 m. Capacity at F.S.L (534.47 m) is approximately 65,000 da³ (SWA Operations 2008).

Water level in Blackstrap Reservoir is influenced mainly by the SSWS, which is opened in the spring and closed for the fall and winter months. The amount of water pumped through the system is dependant upon the requirements downstream and the water levels of the receiving bodies (Sask Water 2008).

Blackstrap Provincial Park is located along the eastern shoreline of Blackstrap Lake south of Highway 11. A popular recreational site, the park has many attractions including a boat launch, fishing, camping, beach volleyball, and other seasonal outdoor activities such as skiing and hiking. Local communities surrounding the lake include the resort Village of Shields, the resort Village of Thode and the Hillcrest Hutterite Colony. Built in 1970 for the 1971 Canada games, Blackstrap 'Mountain' is located centrally within the park.

Blackstrap Reservoir is located within the Moist Mixed Grassland ecoregion in Saskatchewan. Blackstrap Reservoir is located on the Elstow Glacial Lake Plain, which is characterized by hummocky, kettled and gently undulating glaciolacustrine plains (Acton et al. 1998).

1.2 Lake Stewardship & the Blackstrap Watershed Stewards

The Blackstrap Watershed Stewards (BWS) participated in Saskatchewan Watershed Authority's *Lake Stewardship Program* from September 2006 to April 2008. This program focused on supporting activities, projects and public education at lakes with stewardship groups and volunteers. As part of the *Lake Stewardship Program*, Saskatchewan Watershed Authority conducted the water quality monitoring by providing technical support (i.e. sample collection), analytical costs and interpreting water quality measurements for the BWS.

The BWS volunteers are important advocates on behalf of Blackstrap Reservoir and its upland area. The group is incorporated as a non-profit organization and continues to take part in activities and projects which promote education and awareness regarding the aquatic and terrestrial health of Blackstrap Reservoir. Active in the communities and recreational areas around the lake, the BWS aims to inform the public about the water quality of Blackstrap Reservoir and the ways that human activities can positively or negatively impact its water

quality. The group has carried out their goals by providing both the public and permanent residents with informational packages and newsletters.

The vision of the BWS is "...to maintain and improve a healthy watershed including our shoreline and riparian areas through partnerships, education and good stewardship practices." Their mission states that they seek to "...understand and protect fish habitat, to restore and maintain shoreline and to conserve our water resources for the future." In 2006, the group's goals included implementing long term monitoring of the lake's water quality and communicating positive information to educate all lake users on how to keep their lake healthy through good stewardship practices.

2.0 Water Quality Sampling

Water quality monitoring of Blackstrap Reservoir began in 2007 through the cooperation of Saskatchewan Watershed Authority and the BWS. In addition to sampling conducted by Saskatchewan Watershed Authority, this report includes results from periodic sampling by the Ministry of the Environment since 1973. For the purpose of this report, only historical data providing sufficient data and parameters are included in analysis using the Water Quality Index (WQI).

The objective of water quality sampling in 2007 was to provide background (normal or average) water quality values for Blackstrap Reservoir. Though water quality sampling through the Lake Stewardship Program ceased in 2008, the baseline data collected on Blackstrap Reservoir in 2007/2008 along with historical data collected will be of great benefit to better understand the lake's water quality and can be utilized to make more informed decisions about the management and activities in and around the lake.

2.1 Water Quality Frequency and Sampling Sites

The standard lake sampling schedule for Saskatchewan Watershed Authority's *Lake Stewardship Program* includes two winter (January to March) and four summer samples (May to October) per year. Sample sites are divided into *Baseline Stations* and *Shoreline Stations* (Figure 1).

Baseline Station: Baseline stations are generally deep, centrally located sites chosen to represent typical water quality conditions in the lake. Certain parameters (i.e. dissolved oxygen and temperature) are recorded at intervals throughout the depth at the site. Baseline stations are sampled on all six sample dates during the year. Water quality results from baseline stations are used to calculate the WQI score.

Shoreline Stations: Shoreline stations are monitored to determine the effects of local influences on water quality. The locations of shoreline stations were chosen by volunteers from the stewardship group in consultation with Saskatchewan Watershed Authority (Figure 1). They are sampled on summer sample dates only. The water quality results for these shoreline stations are compared to Saskatchewan's *Surface Water Quality Objectives for Recreation and Aesthetics* (Interim Edition, July 2006).

2.2 Water Quality Index: Assessing General Water Quality

The WQI provides a means of assessing the overall quality of lake water in Saskatchewan. To calculate the score, results from water quality sampling are compared to provincial objectives for specific water uses such as irrigation, recreation and the protection of aquatic life. The WQI combines key chemical and biological aspects of water quality (including major ions, nutrients, heavy metals, bacteria, dissolved oxygen, and pH) to define overall water quality and summarize these parameters in a single score.

A single score for each year allows easy comparison of general water quality trends over time and identifies parameters considered important to overall lake health. The WQI score is based on whether or not parameters meet their objectives and takes into account the magnitude and frequency of excursions. Deviation from the objective values used in the index does not necessarily indicate poor lake health or that water quality is worsening. Certain parameters (*i.e.* arsenic, chloride and pH) may naturally exceed the WQI objectives in Saskatchewan lakes due to geologic and hydrologic characteristics of the drainage basin and lake. The WQI does not differentiate ‘natural-source deviation’ or exceedances, which are a result of human influences. As such, it is important to examine lake water quality over time in order to assess if human activity may be impacting lake water quality.¹

¹ For a more complete explanation about the Water Quality Index (WQI) or the parameters used to determine WQI scores, please refer to the “Lake Stewardship Water Quality Guide” online at www.swa.ca.

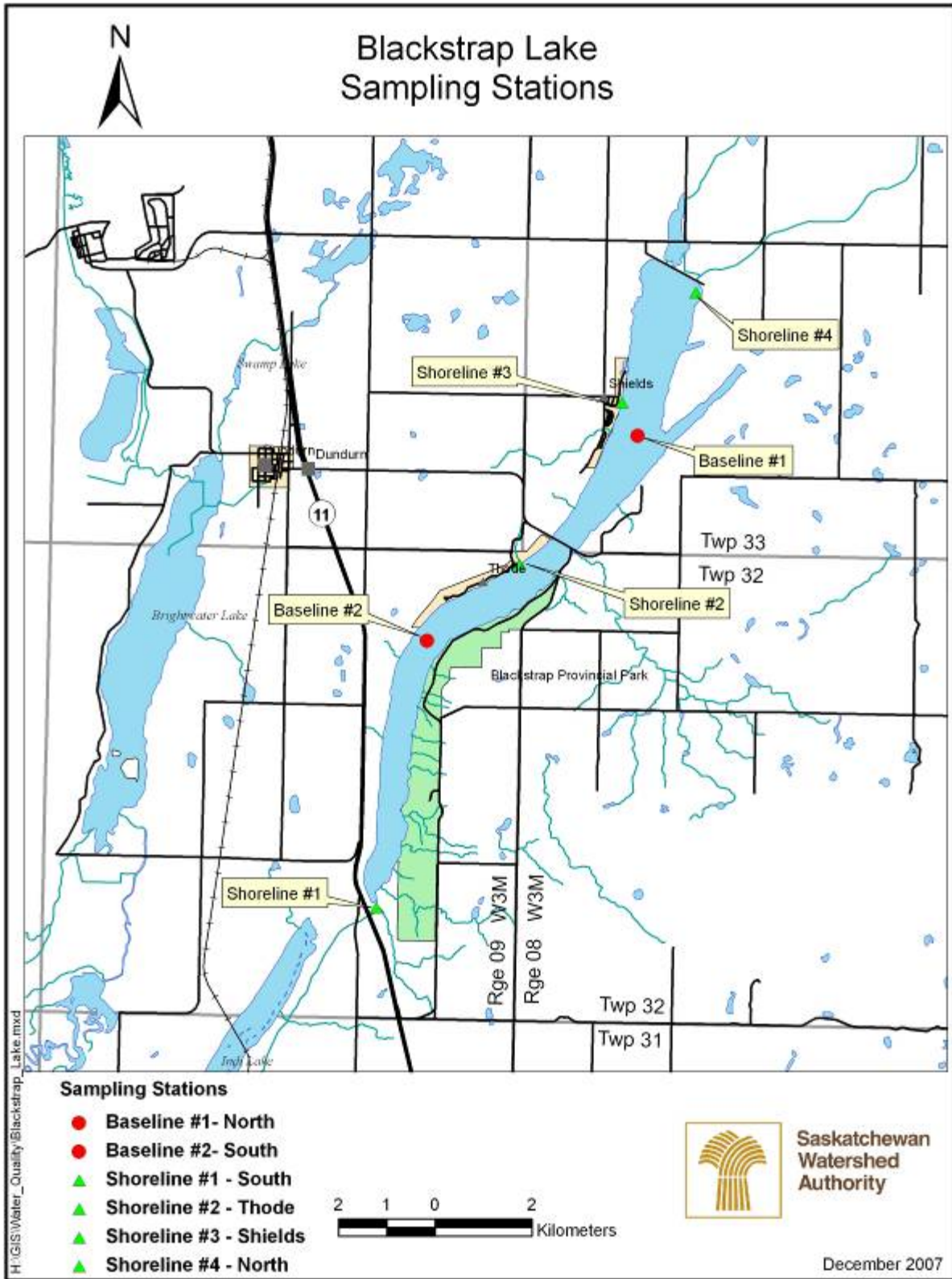


Figure 1: Map of Blackstrap Reservoir 2007-2008 sampling stations. Note: North and South baseline are those established by the Ministry of the Environment in 1973.

3.0 Water Quality Results and Discussion

3.1 Baseline (North and South) Station Summary

The WQI scores for Blackstrap Reservoir Baseline Stations (centre of the lake basins) remained consistent over the sample period from 1973 – 2007 (Figure 2). Though data were limited from 1973 to 1991, data were calculated by pairing two years of data. For instance, where there were not a sufficient number of samples; dates were combined for better representation of the water quality over a two year period.

Though the WQI scores appear to be consistent, it should be noted that WQI scores from 1973 to 1991 do not include metals or *E.coli* and only sporadically measured ions and nutrients. With exception of 2007, years scoring 100% may be over estimated due to lack of sample numbers, lack of parameters tested or both. The score in 2007 includes two winter samples taken by SWA in 2008, which is, therefore, the only year representing the reservoir's water quality all year around.

Blackstrap Reservoir's baseline stations WQI scores are categorized as *good to excellent*. The consistency in both the frequency and magnitude of the parameters identified as "exceeding" the WQI index indicates that these exceedances may not be due to human influences, but rather to natural processes, and may not impair the ecology of Blackstrap Reservoir. Given the data available, only four parameters (ammonia, sodium, total phosphorus and chlorophyll *a*) exceeded objectives in the WQI.

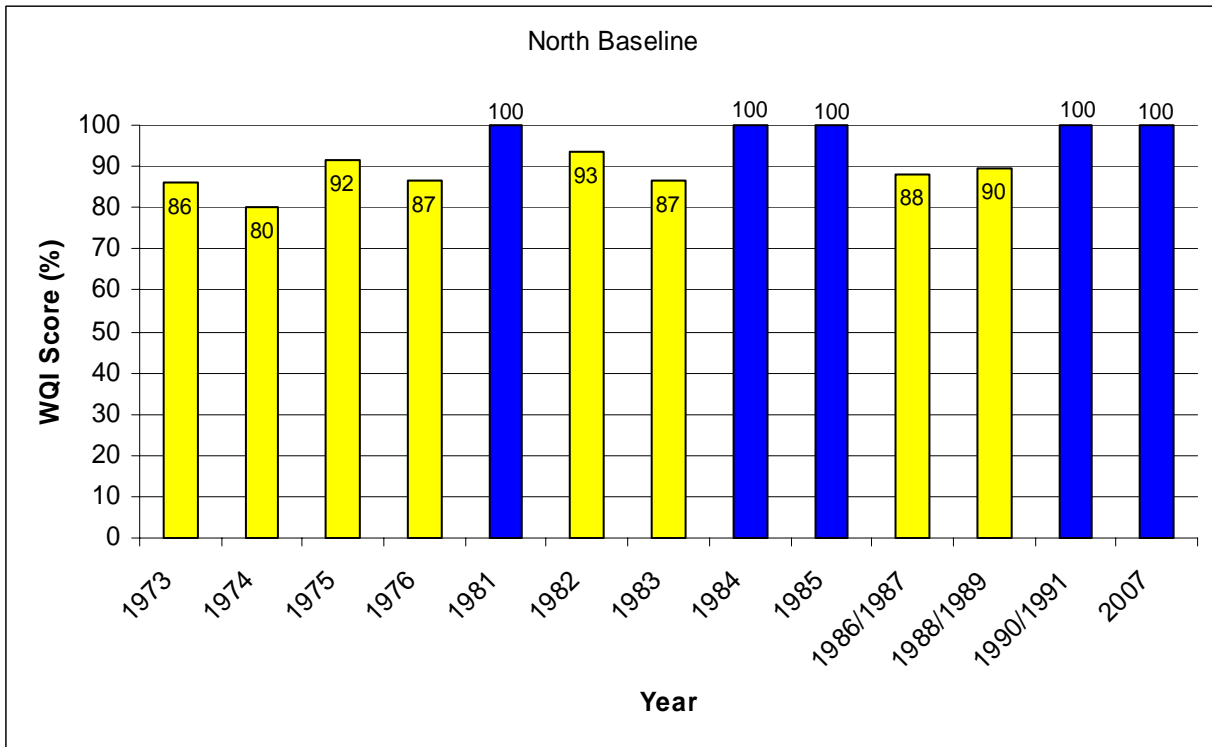
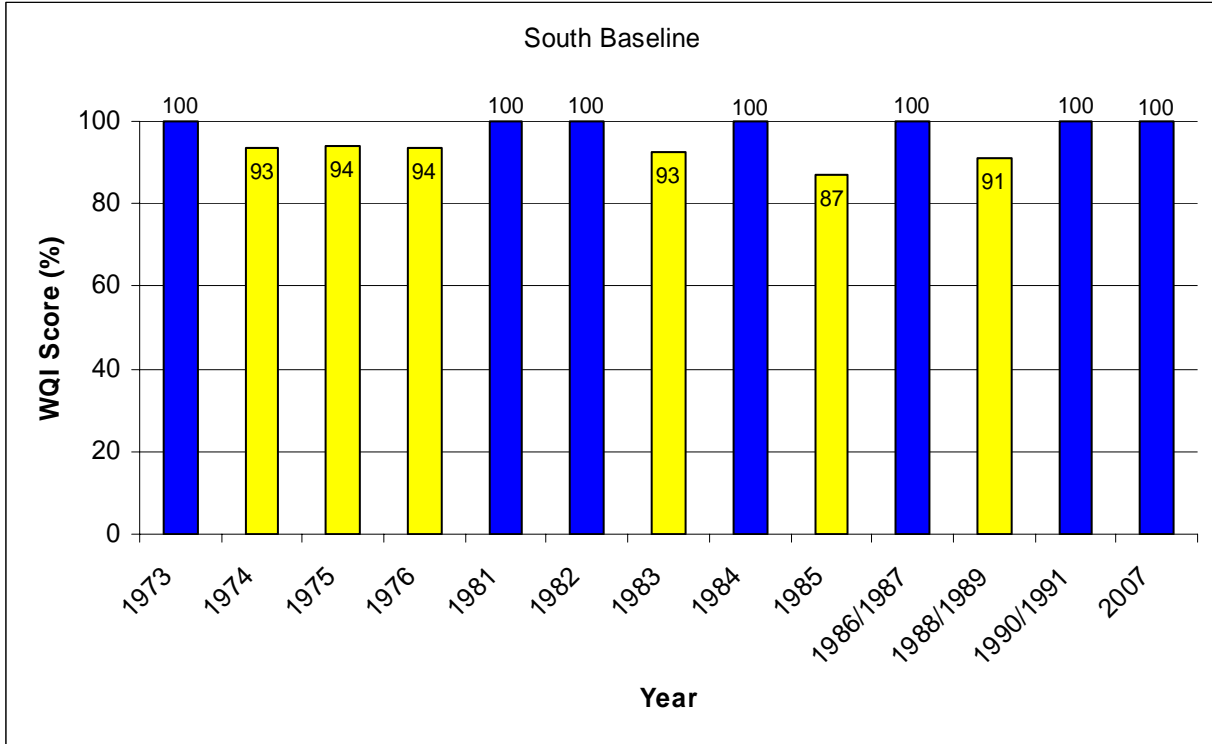


Figure 2: Water Quality Index (WQI) scores for Blackstrap Reservoir - Baseline Stations 1973-2007.
Note: Data provided by Ministry of the Environment from 1973 to 1991. Data collected from 2007-2008 by Saskatchewan Watershed Authority.

3.2 Parameters that Exceeded WQI Objectives

Ammonia

Ammonia is an important nutrient found naturally in lakes throughout Saskatchewan. Ammonia is largely derived from the decomposition of organic matter. Ammonia exists as two forms, unionized and ionized. The relative proportion of each form is dependant on pH and temperature (Trussell 1972). At certain concentrations, the unionized form of ammonia is harmful to aquatic life such as fish. Using the available data, Blackstrap Reservoir's baseline ammonia (which is used to calculate unionized ammonia) ranges seasonally from 0.01 to 1.1 mg/L.

Sodium

Sodium is one of the many ions that make up the ionic composition of the water. Saskatchewan Watershed Authority suggests a target value for sodium of 100 mg/L; however, there are many different acceptable levels of sodium depending on the use of the water (i.e. irrigation or livestock watering). The sodium levels in Blackstrap Lake ranged from 29 to 120 mg/L.

Total Phosphorus

Nutrients are essential for the growth and survival of all organisms. The amount of nutrients in a lake influence how much and what types of life it supports. In aquatic systems nutrients come from a variety of sources including: human activities, natural weathering, inflow, and internal sources (e.g. release from sediment at the lake bottom). Increased nutrients can lead to a variety of problems including algal growth; however, it is important to note that total phosphorus is variable and may change seasonally. As a result of their importance, key nutrients including total phosphorus were monitored as part of the *Lake Stewardship Program*. Total phosphorus in the Blackstrap Reservoir ranged from 0.01 to 0.60 mg/L.

Chlorophyll *a*

Chlorophyll *a* is the primary pigment that plants and algae use to convert sunlight into energy for growth. By determining the amount of chlorophyll *a* you can estimate the algal biomass. Saskatchewan Watershed Authority set a target value for chlorophyll *a* at 50 mg/L. The range for chlorophyll *a* in Blackstrap Lake is from 1 to 61 mg/L.

3.2.1 Trends in Parameters with Exceedances

The north baseline in Blackstrap Lake exceeded objectives more frequently than the south baseline for ammonia, sodium and total phosphorus (see Figure 3). Despite more frequent exceedances in one basin, the concentration of ammonia, total phosphorus and chlorophyll *a* between the two basins are not significantly different. However, with 40.8% more exceedances for sodium in the north basin than the south basin, the concentration of sodium is significantly higher in the north basin when concentration of sodium in the basins is compared ($p=0.000$, t-test for unequal variances). Though not included in the WQI as a parameter of concern, potassium concentrations in the north basin are also significantly higher than the south basin ($p=0.009$, t-test for equal variance).

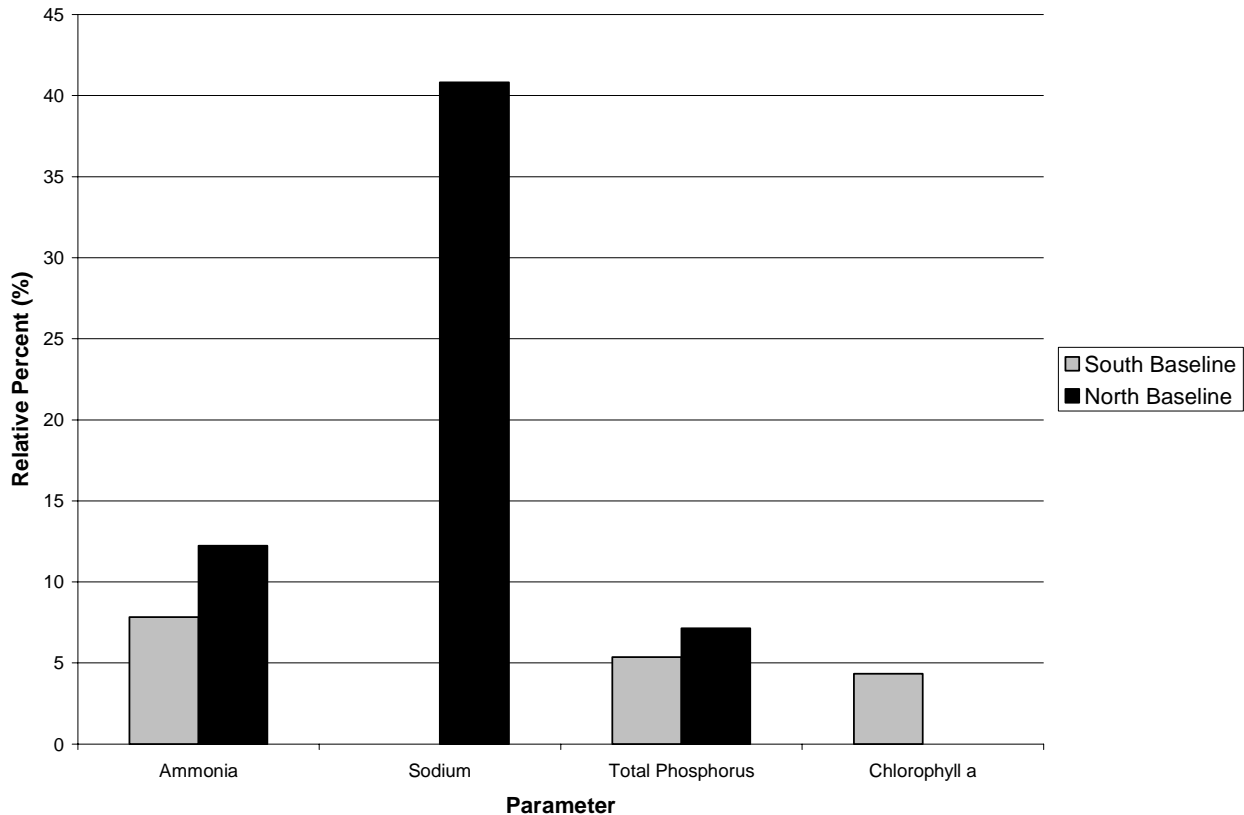


Figure 3: Relative percent of exceedance for four parameters tested in South and North Baseline of Blackstrap Lake from 1973 – 2007.

Conversations with local landowner Ken Qualman (personal communications, Sept 17th, 2008) and SaskWater (D. Frey personal communications, Sept 9th, 2008), revealed that prior to initial flooding of the reservoir in 1967, a large alkali slough was located south of Shields and north of the causeway under what is now Blackstrap Reservoir. With some farming located in the north basin, a portion of the land was also tilled or used for pasture. Therefore, though we can not directly determine the direct source of the sodium and potassium, the initial concentrations may be due to the presence of alkali soils prior to flooding.

In Figure 4, sodium and potassium concentrations appear to decrease from 1973 to 2007, however no significant relationship was found to conclude the trend. Lack of data, natural seasonal variability and changes in water levels throughout the years may contribute to changes seen in the potassium and sodium concentrations. Though they can be utilized differently within their aquatic system, sodium and potassium could be expected to decrease over time due to regular flushing of the reservoir from Lake Diefenbaker each year.

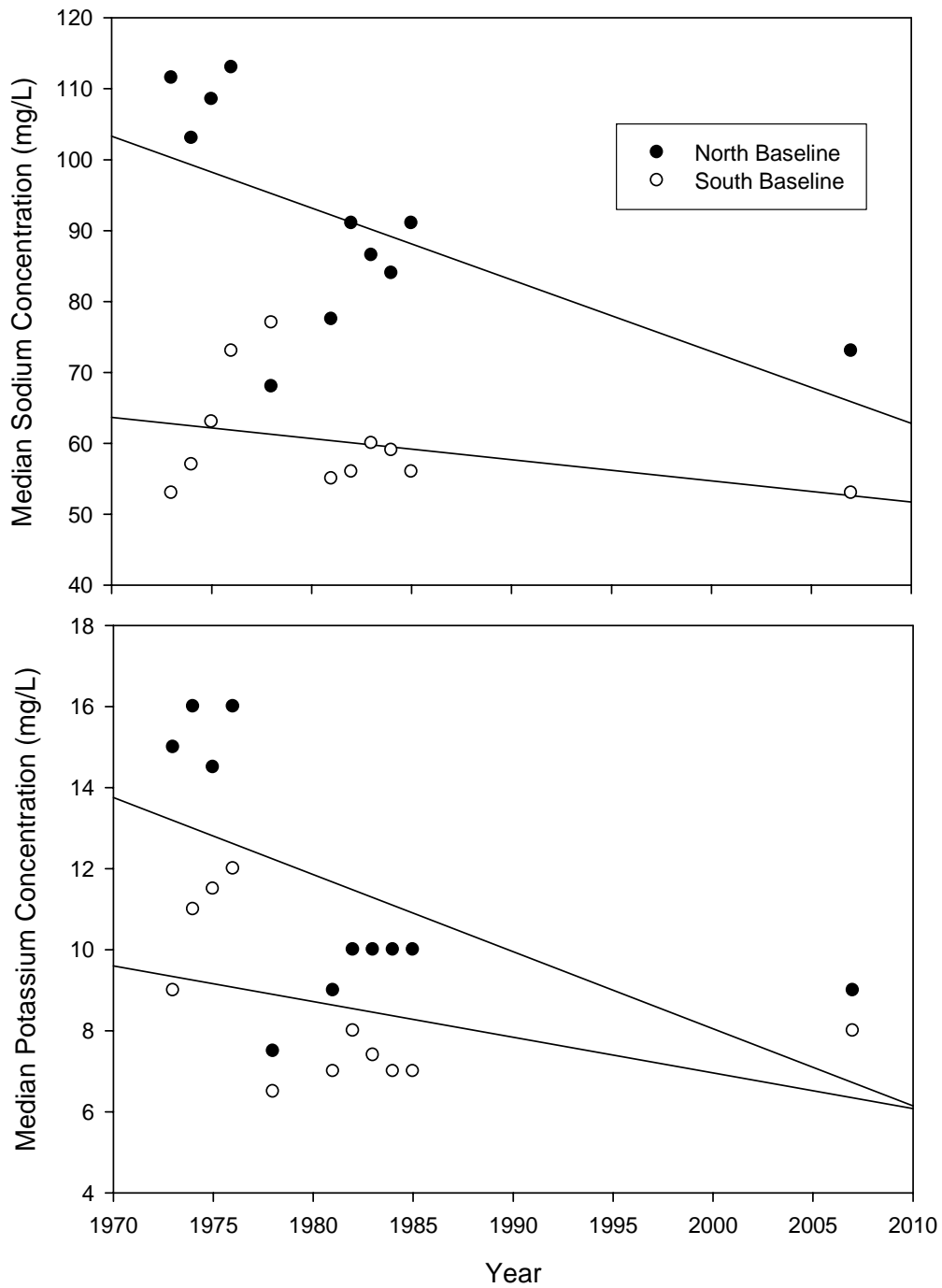


Figure 4: Average concentration of sodium and potassium in both the north and south basins of Blackstrap Reservoir from 1973 – 2007.

3.3 Remaining Parameters Measured for the WQI

Parameters which contribute to the water quality of Blackstrap Reservoir but did not exceed the WQI objectives include: arsenic, chloride, chromium, mercury, dissolved oxygen, herbicides, aluminum, sulphate, fecal coliform bacteria, dissolved nitrate and pH. For a complete description of each parameter and their contribution to water quality please refer to the “Lake Stewardship Water Quality Guide”, which you can find on our website www.swa.ca.

3.4 Field Measurements

Surface water quality parameters measured at the baseline station include five important field measurements which contribute to a better understanding of Blackstrap Reservoir’s water quality. Some of these parameters also contributed to the calculation of the WQI. These five parameters include: dissolved oxygen (DO), temperature, specific conductivity, turbidity and Secchi disk depth.

Dissolved Oxygen & Temperature

Dissolved oxygen concentrations are variable depending on time, weather and temperature. Dissolved oxygen affects both chemical processes and biological organisms within the lake. For example, certain fish species are sensitive to low levels of dissolved oxygen and may experience stress or death due to low levels of oxygen in the water. For the WQI, the objective is 5.5 mg/L of dissolved oxygen for the protection of aquatic life. Profile measurements for dissolved oxygen in Blackstrap Reservoir indicate that it is well oxygenated throughout the year with exception of two circumstances: 1) during the winter months, the deepest two metres experience lower levels of dissolved oxygen due to decomposition on the bottom of the lake similar to that seen in Figure 5, and 2) during calm hot summer days and/or during a period of decreased wind, levels of dissolved oxygen can decrease at all depths because the water is well mixed (very little resistance to mixing) and water temperature is high. In Figure 6, sampling occurred in the early morning, a time with dissolved oxygen can be at its lowest.

Temperature is measured because of the direct/indirect influence it has on other parameters such as dissolved oxygen and specific conductivity. For example, temperature can influence the spatial distribution of fish (i.e. cold water vs. warm water species) and plant growth. Ranging seasonally, temperature values observed at the baselines in Blackstrap Reservoir from 1973 - 2007 varies from 0.2 to 24.0°C.

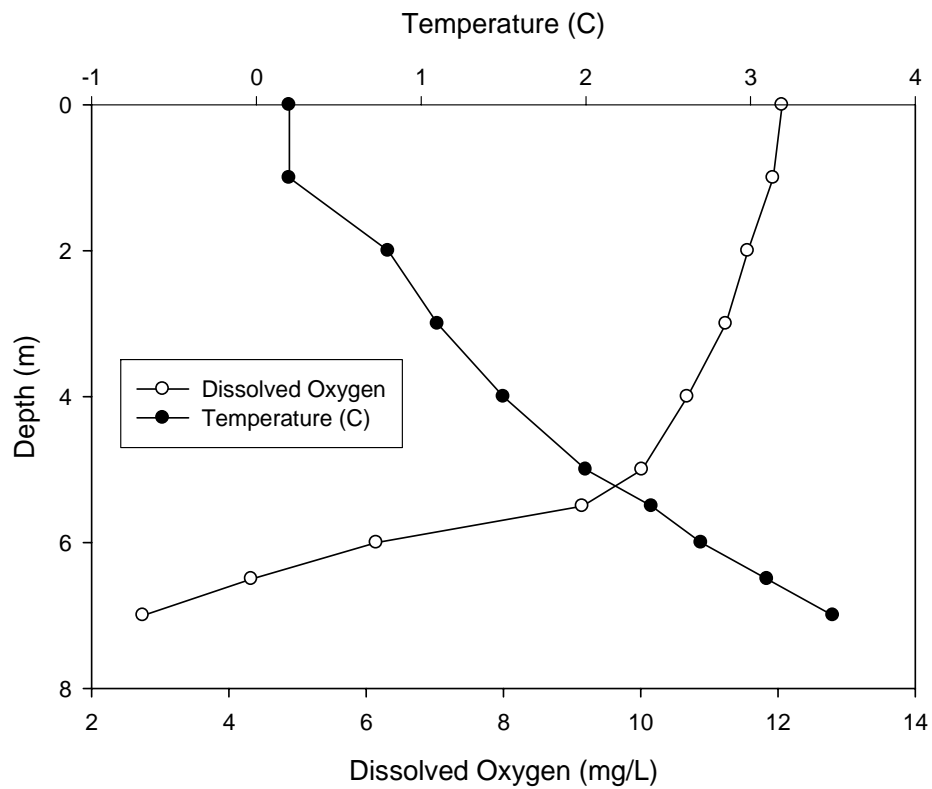


Figure 5: Profile of dissolved oxygen and temperature on February 8th, 2008 at south baseline. Pattern similar in the north basin, indicating that dissolved oxygen levels under 6.0 m depth were below 5.5 mg/L.

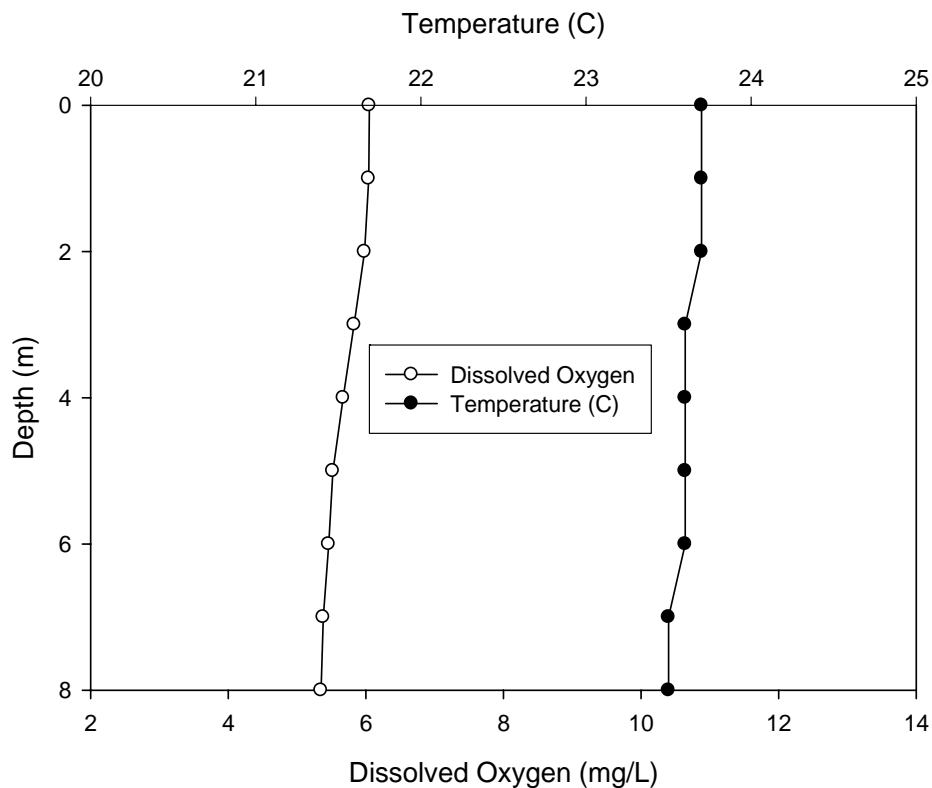


Figure 6: Profile of dissolved oxygen and temperature on July 30th, 2008 at south baseline. Pattern similar in the north basin, indicating that dissolved oxygen levels under 6.0 m depth were below 5.5 mg/L.

Specific Conductivity

Conductivity is a measure of water's ability to conduct an electrical current, which depends on the concentration of dissolved ions in solution. Specific conductivity is calculated using the conductivity of the water (concentration of specific ions) and the water temperature. Influenced by geology, soil composition and inflow from Lake Diefenbaker, specific conductivity in 2007 - 2008 ranged from 600 - 894 $\mu\text{S}/\text{cm}$ and 857 - 1026 $\mu\text{S}/\text{cm}$ in the south and north baselines respectively. Historically, specific conductivity is extremely variable and has ranged from 360 - 1400 $\mu\text{S}/\text{cm}$.

Turbidity

Turbidity is a measure of the water's 'lack' of clarity. A reduction in water clarity may be caused by solids suspended in the water, including: sediment (e.g. during lake overturn) and plankton (small plants and animals). Other sources of turbidity (or lack of water clarity) which are commonly seen closer to shore include: shoreline erosion (due to ice scour or wave action from wind or boat traffic), waste discharge, urban runoff, algal growth, sediment disruption from human activities or bottom feeding organisms. An increase in turbidity decreases light penetration because the particles floating in the water either absorb or scatter the light (Wetzel 2001). For recreational purposes, the surface water objective for turbidity is less than 50 NTU. Turbidity is low (meaning good light penetration and clarity is good) at both baseline stations in Blackstrap Reservoir with values between 0.28 and 4.49 NTU.

Secchi Disk Depth

Secchi disk depth is a direct measure of water transparency and like turbidity is affected by suspended sediment, plankton and water colour. Easily measured with a marked disk and measured rope, the Secchi disk depth can delineate the photic zone (area in which light penetrates) of the lake. This is an important measurement because it indicated the area of the lake in which algae and plants can live. At Blackstrap Reservoir baselines, Secchi disk readings ranged from 2.3 to 2.5 m.

3.5 Shoreline Stations

Blackstrap Reservoir has four shoreline stations chosen for summer monitoring. Blackstrap Reservoir's shoreline stations are located on the south shoreline (Station #1), Thode shoreline (Station #2), Shields shoreline (Station #3) and on the north shoreline (Station #4) (Figure 1). Shoreline stations at Blackstrap Reservoir were sampled during the summer of 2007. Water quality measurements at shoreline sampling stations were compared to Saskatchewan's *Surface Water Quality Objectives for Recreation and Aesthetics* (2006). There are numeric objectives for clarity (Secchi depth), *E. coli* and turbidity. While chlorophyll *a* values are compared to the Saskatchewan Watershed Authority target value (SWA 2007).

Secchi Disk Depth

The Saskatchewan *Surface Water Quality Objectives* (2006), state that for bathing waters the Secchi disk depth should be at least 1.2 m. Water clarity is affected by factors such as wave action, suspended particles (sediment or algae) and the amount of coloured organic material in the water. Factors decreasing the Secchi disk depth can be more pronounced near shore, due to

increased wave action, increased temperature (which may promote algal growth) and influences from upland activities (i.e. runoff and human activities). Secchi depth was not measured at Thode and south shoreline stations because either the bottom of the lake was visible at depths greater than 1.2 m or it was too windy and difficult to accurately take a measurement. The south shoreline had a Secchi reading of 65 cm on September 4th, 2007 and Shield shoreline met the objective measuring 2.0 m on July 30th, 2007.

Bacteria

Escherichia coli (*E. coli*) is a species of bacteria found in the lower intestines of animals and people. *Escherichia coli* species are commonly detected in surface water because people, pets, livestock, birds and wild animals come into contact with the water. The recreational guideline for *E.coli* states that “The geometric mean of at least five samples taken during a period not to exceed 30 days should not exceed 2000 *E. coli* per litre.” (SE 2006). Therefore, all samples from the shoreline stations in Blackstrap Reservoir are below the guideline as most results were well below 100 counts/100mL: however, our method of testing does not meet the methodological requirements as stated by the *Surface Water Quality Objectives* for the purpose of recreation (SE 2006). Regardless of the origin, it is always helpful for humans to take steps to minimize contamination (i.e. proper septic tank maintenance and keeping pets out of the water).

Turbidity

For recreational purposes, the surface water objective for turbidity is less than 50 NTU. All sites had readings below 10 NTU so none of the shorelines exceeded the objective set for recreation. Similar to water clarity, turbidity is influenced by water movement, wind, suspended particles and organic matter.

Chlorophyll *a*

The relative amount of algae in surface water is assessed by measuring Chlorophyll *a* (the primary pigment that plants and algae use to convert sunlight into energy for growth). Chlorophyll *a* is an indicator of the productivity of the lake. Lakes high in nutrients tend to have more algae or macrophyte growth. Blackstrap Reservoir’s shoreline stations ranged from 4.52-26.14 µg/L and were therefore below the <50 µg/L objective for Chlorophyll *a*. Shoreline stations may have higher algae concentrations than baseline stations due to factors such as wind and wave action which can lead to the congregation of algae. Calm warm days can also lead to localized algal blooms thereby increasing the chlorophyll *a* present.

When compared to the objectives used to calculate the WQI, most of the shoreline stations at Blackstrap Reservoir have similar water quality to the baseline stations with exception of the south shoreline. Located at the inflow to the reservoir, the south shoreline’s water quality is good when flowing from the diversion channel; however, when the flow is stopped the water quality at the south shoreline is no longer representative of flow from Diefenbaker but rather the stagnant water in the channel or runoff from adjacent lands.

A WQI index score is not calculated for shoreline stations because some parameters required for the index (i.e., metals) are not measured at shoreline stations. Second, shoreline water quality is much more indicative of the local conditions than water quality of the entire lake.

4.0 Recommendations

Blackstrap Reservoir was sampled through the *Lake Stewardship Program* from 2007 - 2008 completing four summer samples and one winter sample. Though the program ceased in 2008, the information collected thus far (including the historical data) provides lake users, residents, managers and other interested parties with an increased understanding of Blackstrap Reservoir's water quality. Saskatchewan Watershed Authority encourages the group to continue educating themselves and other lake users about the water quality of Blackstrap Reservoir and how to protect it.

To maintain the water quality of Blackstrap Reservoir, it is recommended that recreational users and upland stakeholders (including cabin owners) minimize nutrient additions to the lake. Fertilizer use and disruption of natural vegetation and shoreline should be kept to a minimum. Enhancement of shoreline buffer zones to slow erosion and slow the flow of surface runoff to Blackstrap Reservoir will help reduce the amount of nutrients and other contaminants entering the lake.

The Saskatchewan Watershed Authority encourages the continuation of public education and outreach by the *Blackstrap Reservoir Watershed Stewards* to teach lake users and stakeholders to follow healthy shoreline living practices such as those outlined in *On the Living Edge – Your Handbook for Waterfront Living* (Kipp & Gallaway 2003).

5.0 References Cited

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Data Tables

2007 – 2008

Blackstrap Lake Baseline Station – South Dissolved Oxygen, Temperature and Conductivity Profile, 2007 - 2008					
Date (d/m/y)	Depth (m)	Dissolved Oxygen		Water Temperature (°C)	Conductivity (µS/cm)
		(mg/L)	(% sat.)		
27/06/07	0.5	6.37	66.2	18.3	699.0
	1.0	7.36	79.8	18.2	890.0
	2.0	7.33	76.8	17.8	889.0
	3.0	7.32	77.0	17.8	888.0
	4.0	7.24	75.4	17.7	889.0
	5.0	7.09	73.7	17.6	888.0
	6.0	7.16	73.8	17.6	886.0
	7.0	6.99	72.5	17.5	886.0
	8.0	6.49	67.6	17.5	891.0
30/07/07	0.0	6.05	71.9	23.7	716.0
	1.0	6.04	70.9	23.7	717.0
	2.0	5.98	70.6	23.7	717.0
	3.0	5.83	69.2	23.6	718.0
	4.0	5.67	67.0	23.6	719.0
	5.0	5.52	65.3	23.6	719.0
	6.0	5.46	64.0	23.6	719.0
	7.0	5.38	67.5	23.5	719.0
	8.0	5.35	63.4	23.5	719.0
	9.0	5.27	61.9	23.4	718.0
04/09/07	0.0	7.10	na	17.4	625.0
	1.0	7.01		17.4	625.0
	2.0	6.90		17.4	624.0
	3.0	6.98		17.4	624.0
	4.0	6.96		17.1	620.0
	5.0	6.53		17.0	618.0
	6.0	6.40		17.0	618.0
	7.5	6.03		16.9	600.0

Table 1: Baseline Station – South Dissolved Oxygen, Temperature and Conductivity Profile, 2007 - 2008

Blackstrap Lake Baseline Station – South Dissolved Oxygen, Temperature and Conductivity Profile, 2007 - 2008					
Date (d/m/y)	Depth (m)	Dissolved Oxygen		Water Temperature (°C)	Conductivity (µS/cm)
		(mg/L)	(% sat.)		
17/10/07	0.0	8.57	na	7.8	481.0
	1.0	8.51		7.9	485.0
	2.0	8.56		7.9	485.0
	3.0	8.51		7.9	485.0
	4.0	8.42		7.9	485.0
	5.0	8.60		7.9	485.0
	6.0	8.48		7.9	485.0
	7.0	8.47		7.9	484.0
26/02/08	0.0	12.06	na	0.2	457.4
	1.0	11.93		0.2	455.4
	2.0	11.56		0.8	459.1
	3.0	11.24		1.1	461.7
	4.0	10.68		1.5	465.8
	5.0	10.02		2.0	469.7
	5.5	9.15		2.4	475.0
	6.0	6.15		2.7	478.0
	6.5	4.33		3.1	485.0
	7.0	2.75		3.5	494.0

Table 2: Baseline Station – South Dissolved Oxygen, Temperature and Conductivity Profile, 2007 - 2008

Blackstrap Lake Baseline Station – North Dissolved Oxygen, Temperature and Conductivity Profile, 2007 - 2008					
Date (d/m/y)	Depth (m)	Dissolved Oxygen		Water Temperature (°C)	Conductivity (µS/cm)
		(mg/L)	(% sat.)		
27/06/07	0.0	7.23	74.5	18.6	1,019
	1.0	7.33	76.8	18.3	1,020
	2.0	7.28	77.4	17.9	1,020
	3.0	6.80	73.4	17.7	1,020
	4.0	6.65	70.9	17.6	1,020
	5.0	6.65	69.9	17.6	1,020
	6.0	6.40	67.3	17.5	1,021
	7.0	5.73	60.0	17.4	1,025
	8.0	5.69	59.7	17.3	1,026
03/07/07	0	6.14	73.6	24.0	857
	1	6.09	72.9	24.0	857
	2	6.08	71.7	24.0	857
	3	5.97	70.9	23.8	859
	4	5.85	69.8	23.7	857
	5	5.66	67.0	23.6	857
	6	5.55	65.6	23.5	857
	7	4.71	55.7	23.3	858
	8	4.65	54.3	23.3	859
	9	3.38	41.9	23.0	861
04/09/07	1	9.03	na	17.5	755
	2	8.80		17.4	753
	3	8.92		16.9	743
	4	8.85		16.7	739
	5	8.42		16.6	738
	6	8.22		16.5	737
	7	8.04		16.5	736
	8	7.86		16.4	736

Table 3: Baseline Station – North Dissolved Oxygen, Temperature and Conductivity Profile, 2007 - 2008

Blackstrap Lake Baseline Station – North Dissolved Oxygen, Temperature and Conductivity Profile, 2007 - 2008					
Date (d/m/y)	Depth (m)	Dissolved Oxygen		Water Temperature (°C)	Conductivity (µS/cm)
		(mg/L)	(% sat.)		
17/10/07	0	8.61	na	8.00	863.32
	1	8.68		8.00	861.84
	2	8.62		8.00	861.84
	3	8.55		8.00	861.84
	4	8.58		8.02	861.35
	5	8.67		8.00	861.84
26/02/08	0	na	na	0.0	991.39
	1	10.94		0.2	991.79
	2	10.88		0.5	1005.54
	3	10.34		0.7	1007.71
	4	9.35		0.7	1026.37
	5	8.89		1.3	1015.84
	6	8.51		1.8	1009.19
	7	6.55		2.2	1011.48
	7.5	5.45		2.6	1011.95
	8.0	3.13		2.9	1019.23

Table 4: Baseline Station – North Dissolved Oxygen, Temperature and Conductivity Profile, 2007 - 2008

Blackstrap Lake Baseline Station - South Surface Parameters					
Parameters	2007				2008
	June 28	July 30	Sept 4	Oct 17	Feb 26
Nutrients (mg/L)					
Dissolved Organic Carbon	na	8.1	8.0	7.7	8.0
Nitrate, as Nitrogen	<0.04	<0.04	0.06	0.14	0.24
Ammonia, as Nitrogen	0.02	0.02	0.02	<0.02	0.04
Total Kjeldahl Nitrogen	0.7	0.7	0.9	0.7	0.7
Total Phosphorous	0.03	0.06	0.06	0.06	0.08
Ortho-Phosphate, as P	<0.02	0.06	0.05	0.05	0.06
Solids (mg/L)					
Total Dissolved	562	547	543	576	691
Suspended, Fixed	1	1	2	2	<1
Suspended, Volatile	1	2	4	1	1
Suspended, Total	2	3	6	3	1
Bacteria (orgs/100 mL)					
E. Coli	<10	<10	1	<10	<10
Total Coliform	<10	364	37	20	<10
Major Ions (mg/L)					
Alkalinity, Total	172	168	164	169	197
Alkalinity, Phenol	4.58	6.00	2.00	0.00	0.00
Bicarbonate	199	190	195	206	240
Calcium	55	57	52	56	70
Carbonate	5	7	2	0	0
Chloride	13.5	13.2	13.1	14.1	16.1
Fluoride	0.19	0.23	0.20	0.22	0.22
Hardness, Total	269	282	262	276	344
Magnesium	32	34	32	33	41
Potassium	8	9	8	8	10
Sodium	51	55	51	53	64
Sulphate	198.4	181.7	190.3	205.8	250.1
Other					
Chlorophyll <i>a</i> (µg/L)	<0.20	15.41	21.78	5.34	<0.20
Conductivity (µS/cm)	696	695	723	736	850
pH (pH units)	8.4	8.4	8.3	8.2	8.1
Turbidity (NTU)	2.25	3.50	3.60	2.30	2.00
Biochemical Oxygen Demand (mg/L)	<2.0	<2.0	2.5	<2.0	<2.0
Chemical Oxygen Demand (mg/L)	23.1	19.5	17.6	16.2	18.7

Table 5: Baseline Station – South Surface Parameters

Blackstrap Lake Baseline Station - South Surface Parameters					
Parameters	2007				2008
	June 28	July 30	Sept 4	Oct 17	Feb 26
Field Data					
Time	10:55	10:25	9:00	13:30	10:00
Air Temperature (°C)	15.0	27.0	15.0	13.5	-10.0
pH (pH units)	8.381	8.515	8.724	8.430	8.09
Turbidity (NTU)	2.10	2.4	1.9	4.49	0.60
Secchi Disk Transparency (m)	2.4	2.5	na	na	0.0
Cloud Cover (%)	30	50	50	100	100
Wind Speed (km/h)	5.0	20-30	20-30	15-20	9.5

Table 6: Baseline Station – South Surface Parameters

Blackstrap Lake Baseline Station - South Bottom Parameters			
Parameters	June 28	September 4	February 26
Nutrients (mg/L)			
Dissolved Organic Carbon	na	7.9	7.8
Nitrate, as Nitrogen	<0.04	0.07	0.32
Ammonia, as Nitrogen	<0.02	0.04	0.02
Total Kjeldahl Nitrogen	0.7	0.8	0.6
Total Phosphorous	0.08	0.06	0.10
Ortho-Phosphate, as P	<0.02	0.05	0.09
Solids (mg/L)			
Total Dissolved	559	542	666
Suspended, Fixed	22	1	1
Suspended, Volatile	5	3	1
Suspended, Total	27	4	2
Bacteria (orgs/100 mL)			
E. Coli	<10	<1	<10
Total Coliform	63	161	<10
Major Ions (mg/L)			
Alkalinity, Total	171	163	191
Alkalinity, Phenol	3.22	2.00	0.00
Bicarbonate	201	194	233
Calcium	55	52	69
Chloride	13.3	13.1	15.2
Fluoride	0.18	0.20	0.23
Hardness, Total	269	262	333
Magnesium	32	32	39
Potassium	8	8	9
Sodium	51	51	61
Sulphate	195.0	189.4	239.5
Other			
Chlorophyll <i>a</i> (µg/L)	7.41	15.56	<0.20
Conductivity (µS/cm)	696	717	826
pH (pH units)	8.4	8.3	7.9
Turbidity (NTU)	16.4	7.5	2.7
Biochemical Oxygen Demand (mg/L)	<2	<2	<2
Chemical Oxygen Demand (mg/L)	21.8	25.9	15.4

Table 7: Baseline Station – South Bottom Parameters

Blackstrap Lake Baseline Station – South Surface Metal Parameters					
Parameters	2007				2008
	June 25	July 30	Sept 4	Oct 17	Feb 26
Metals (mg/L)					
Mercury (µg/L)	<0.05	<0.05	<0.05	<0.05	<0.05
Aluminum	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (µg/L)	1.3	na	2.2	1.9	1.9
Barium	0.10	0.088	0.091	0.091	0.110
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	0.076	0.076	0.083	0.081	0.095
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	<0.001	<0.001	<0.001	0.001	0.001
Iron	0.030	0.028	0.024	0.042	0.010
Lead	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	0.014	0.045	0.011	0.006	0.003
Molybdenum	0.002	<0.001	0.002	0.002	0.003
Nickel	<0.001	0.001	0.001	0.002	<0.001
Phosphorous	0.01	0.03	0.02	0.03	0.03
Silicon, Soluble	0.76	3.60	4.40	4.20	4.6
Silver	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	0.37	0.36	0.36	0.37	0.44
Titanium	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	<0.001	<0.001	0.001	<0.001	<0.001
Zinc	<0.005	<0.005	<0.005	<0.005	<0.005
Zirconium	<0.001	<0.001	<0.001	<0.001	<0.001

Table 8: Baseline Station – South Surface Metal Parameters

Blackstrap Lake Baseline Station - North Surface Parameters					
Parameters	2007				2008
	June 28	July 30	Sept 4	Oct 17	Feb 28
Nutrients (mg/L)					
Dissolved Organic Carbon	na	8.4	8.0	7.9	8.8
Nitrate, as Nitrogen	<0.04	<0.04	<0.04	<0.04	0.09
Ammonia, as Nitrogen	<0.02	<0.02	<0.02	<0.02	0.06
Total Kjeldahl Nitrogen	0.7	0.7	0.8	0.7	0.7
Total Phosphorous	0.05	0.06	0.07	0.05	0.07
Ortho-Phosphate, as P	0.05	0.06	0.06	0.05	0.06
Solids (mg/L)					
Total Dissolved	655	652	655	681	804
Suspended, Fixed	<1	1	<1	2	<1
Suspended, Volatile	2	1	3	2	<1
Suspended, Total	2	2	3	4	<1
Bacteria (orgs/100 mL)					
E. Coli	<10	<10	3	31	<10
Total Coliform	<10	262	61	173	<10
Major Ions (mg/L)					
Alkalinity, Total	180	176	177	178	207
Alkalinity, Phenol	3.38	9.00	9.00	4.00	0.00
Bicarbonate	211	193	194	207	253
Calcium	54	59	55	56	69
Carbonate	4	11	11	5	0
Chloride	19.4	19.0	19.4	20.3	22.3
Fluoride	0.22	0.25	0.23	0.24	0.24
Hardness, Total	304	333	310	317	382
Magnesium	41	45	42	43	51
Potassium	8	9	9	9	10
Sodium	67	77	72	73	83
Sulphate	250.6	239.4	253.0	268.0	316.1
Other					
Chlorophyll <i>a</i> (µg/L)	5.11	16.97	11.48	11.46	5.97
Conductivity (µS/cm)	818	823	866	873	999
pH (pH units)	8.4	8.5	8.6	8.4	8.1
Turbidity (NTU)	2.44	1.78	2.50	2.30	0.50
Biochemical Oxygen Demand (mg/L)	<2	na	<2	<2	<2
Chemical Oxygen Demand (mg/L)	19.8	19.5	17.2	23.0	17.6

Table 9: Baseline Station – North Surface Parameters

Blackstrap Lake Baseline Station - North Surface Parameters					
Parameters	2007				2008
	June 28	July 30	Sept 4	Oct 17	Feb 28
Field Data					
Time	12:00	8:15	7:36	13:00	12:00
pH (pH units)	8.308	8.505	8.434	8.600	8.230
Turbidity (NTU)	2.08	1.78	2.11	3.20	0.28
Secchi Disk Transparency (m)	2.3	2.5	na	na	na
Cloud Cover (%)	25	30	5	100	5
Wind Speed (km/h)	<5	20	5-10	15-20	12

Table 10: Baseline Station – North Surface Parameters

Blackstrap Lake Baseline Station – North Surface Metal Parameters					
Parameters	2007				2008
	June 25	July 30	Sept 4	Oct 17	Feb 26
Metals (mg/L)					
Mercury (µg/L)	<0.05	<0.05	<0.05	<0.05	<0.05
Aluminum	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (µg/L)	1.7	na	2.6	2.2	2.2
Barium	0.110	0.100	0.099	0.096	0.12
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	0.087	0.085	0.095	0.098	0.110
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	<0.001	<0.001	<0.001	0.002	<0.001
Iron	0.031	0.013	0.018	0.033	0.005
Lead	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	0.009	0.039	0.012	0.004	0.010
Molybdenum	0.003	<0.001	0.002	0.002	0.002
Nickel	<0.001	0.002	0.002	0.002	<0.001
Phosphorous	0.01	0.02	0.02	0.02	0.02
Silicon, Soluble	4.6	6.0	6.6	4.7	4.5
Silver	<0.004	<0.001	<0.001	<0.001	<0.001
Strontium	0.41	0.41	0.41	0.41	0.48
Titanium	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	<0.005	<0.005	<0.005	<0.005	<0.005
Zirconium	<0.001	<0.001	<0.001	<0.001	<0.001

Table 11: Baseline Station – North Surface Metal Parameters

Blackstrap Lake Baseline Station - North Bottom Parameters				
Parameters	2007			2008
	June 28	July 30	Sept 4	Feb 26
Nutrients (mg/L)				
Dissolved Organic Carbon	na	8.2	8.0	8.8
Nitrate, as Nitrogen	<0.04	<0.04	<0.04	0.15
Ammonia, as Nitrogen	<0.02	<0.02	<0.02	0.07
Total Kjeldahl Nitrogen	0.8	0.6	0.7	0.8
Total Phosphorous	0.06	0.12	0.07	0.08
Ortho-Phosphate, as P	0.05	0.09	0.06	0.07
Solids (mg/L)				
Total Dissolved	661	666	650	802
Suspended, Fixed	2	22	1	<1
Suspended, Volatile	2	5	2	1
Suspended, Total	4	27	3	1
Bacteria (orgs/100 mL)				
E. Coli	<10	<10	<1	<10
Total Coliform	173	197	88	<10
Major Ions (mg/L)				
Alkalinity, Total	181	178	175	206
Alkalinity, Phenol	0.00	0.00	7.00	0.00
Bicarbonate	221	217	196	251
Calcium	54	59	54	69
Chloride	19.2	18.9	19.1	22.4
Fluoride	0.22	0.25	0.22	0.24
Hardness, Total	304	333	308	382
Magnesium	41	45	42	51
Potassium	8	9	9	10
Sodium	67	76	70	83
Sulphate	250.4	240.6	251.5	315.0
Other				
Chlorophyll <i>a</i> (µg/L)	4.60	17.11	5.99	<0.20
Conductivity (µS/cm)	820	830	865	1000
pH (pH units)	8.3	8.2	8.5	8.0
Turbidity (NTU)	3.82	13.90	2.80	0.9
Biochemical Oxygen Demand (mg/L)	<2	<2	<2	<2
Chemical Oxygen Demand (mg/L)	20.9	20.1	17.7	31.4

Table 12: Baseline Station – North Bottom Parameters

Blackstrap Lake Shoreline Station - South 2007 Surface Parameters				
	June 28	July 30	Sept 4*	Oct 17*
Nutrients (mg/L)				
Dissolved Organic Carbon	14.5	8.3	9.3	8.9
Nitrate, as Nitrogen	<0.04	<0.04	0.08	0.04
Ammonia, as Nitrogen	<0.02	<0.02	0.03	0.02
Total Kjeldahl Nitrogen	0.7	0.7	0.7	0.5
Total Phosphorous	0.03	0.07	0.20	0.15
Ortho-Phosphate, as P	0.02	0.06	0.14	0.14
Solids (mg/L)				
Dissolved, Total	555	515	1,814	2,041
Suspended, Fixed	1	1	4	11
Suspended, Volatile	2	3	11	2
Suspended, Total	3	4	11	13
Bacteria (orgs/100 mL)				
E. Coli	<10	<10	88	10
Total Coliform	52	613	4,611	842
Major Ions (mg/L)				
Alkalinity, Total	170	161	340	389
Alkalinity, Phenol	4.58	6.00	0.00	0.00
Bicarbonate	196	182	415	475
Calcium	54	53	259	308
Chloride	13.4	12.4	27.8	29.5
Fluoride	0.19	0.18	0.25	0.28
Hardness, Total	267	264	1,141	1,325
Magnesium	32	32	120	135
Potassium	8	9	12	12
Sodium	50	51	73	73
Sulphate	197.0	168.6	907.6	1,008.7
Other				
Chlorophyll <i>a</i> (µg/L)	5.71	10.37	26.14	6.03
Conductivity (µg/L)	693	665	2,015	2,198
pH (pH units)	8.4	8.5	8.2	8.0
Turbidity (NTU)	2.46	2.73	11.00	9.20
Biochemical Oxygen Demand (mg/L)	<2.0	2.0	2.0	<2.0
Chemical Oxygen Demand (mg/L)	17.7	17.9	21.5	14.4

*new location chosen at south bridge

Table 13: Shoreline Station – South 2007 Surface Parameters

Blackstrap Lake Shoreline Station - South 2007 Surface Parameters				
	June 27	July 30	Sept 4*	Oct 4*
Field Observations				
Time	10:30	9:55	10:45	9:34
Air Temperature (°C)	15.0	25.0	20.0	10.4
Water Temperature (°C)	18.1	23.4	15.3	6.3
Dissolved Oxygen (mg/L)	6.55	7.46	7.00	9.65
Dissolved Oxygen (% sat)	69.3	87.5	na	na
Conductivity (µS/cm)	695	680	1,953	2,189
pH (pH units)	8.198	8.026	8.717	8.231
Turbidity (NTU)	1.88	1.94	9.32	9.58
Cloud Cover (%)	20	90	50	100
Wind Speed (km/hr)	<5	10	20	5-10

*new location chosen at south bridge within the channel

Table 14: Shoreline Station – South 2007 Surface Parameters

Blackstrap Lake Shoreline Station - Shields 2007 Surface Parameters				
	June 28	July 30	Sept 4	Oct 17
Field Observations				
Time	12:00	9:45	8:30	11:00
Air Temperature (°C)	15	25	20	10
Water Temperature (°C)	19.0	24.3	18.4	7.1
Dissolved Oxygen (mg/L)	7.3	5.80	9.61	10.38
Dissolved Oxygen (% sat)	78.7	70.0	na	na
Conductivity (µS/cm)	1,017	854	769	894
pH (pH units)	8.321	8.570	8.911	8.991
Turbidity (NTU)	2.18	1.97	1.43	9.99
Secchi Disk (m)	na	2.0	na	na
Wind Speed (km/h)	5	20-30	20	10-15
Cloud Cover (%)	20	65	50	100

Table 15: Shoreline Station – Shields 2007 Surface Parameters

Blackstrap Lake Shoreline Station North 2007 Surface Parameters	
	October 17
Field Observations	
Time	11:30
Air Temperature (°C)	10
Water Temperature (°C)	7.10
Dissolved Oxygen (mg/L)	10.08
Conductivity (µS/cm)	893
pH (pH units)	8.58
Turbidity (NTU)	7.06
Wind Speed (km/h)	15-20
Cloud Cover (%)	100

Table 16: Shoreline Station North 2007 Surface Parameters

Blackstrap Lake Shoreline Station - Thode 2007 Surface Parameters				
	June 27	July 30	Sept 4	Oct 4
Field Observations				
Time	11:40	11:45	10:00	10:30
Air Temperature (°C)	15	30	18	10
Water Temperature (°C)	18.6	24.4	17.1	7.9
Dissolved Oxygen (mg/L)	7.61	4.35	6.06	10.44
Dissolved Oxygen (% sat)	86.2	55.3	na	na
Conductivity (µS/cm)	894	708	623	755
pH (pH units)	8.437	8.440	8.582	8.561
Turbidity (NTU)	2.70	6.48	3.51	3.10
Wind Speed (km/h)	5	10-15	25-30	5-15
Cloud Cover (%)	30	10	80	100

Table 17: Shoreline Station - Thode 2007 Surface Parameters

Blackstrap Lake Shoreline Station - Shields 2007 Surface Parameters				
	June 28	July 30	Sept 4	Oct 17
Nutrients (mg/L)				
Dissolved Organic Carbon	15.4	8.6	8.3	8.5
Nitrate, as Nitrogen	<0.04	<0.04	<0.04	<0.04
Ammonia, as Nitrogen	<0.02	<0.02	<0.02	<0.02
Total Kjeldahl Nitrogen	0.7	0.7	0.8	1.0
Total Phosphorous	0.05	0.05	0.06	0.08
Ortho-Phosphate, as P	0.05	0.05	0.06	0.04
Solids (mg/L)				
Dissolved, Total	652	649	646	683
Suspended, Fixed	<1	1	<1	9
Suspended, Volatile	2	1	2	6
Suspended, Total	2	2	2	15
Bacteria (orgs/100 mL)				
E. Coli	<10	<10	<1	<10
Total Coliform	<10	421	46	3,076
Major Ions (mg/L)				
Alkalinity, Total	180	175	176	182
Alkalinity, Phenol	3.38	10.00	13.00	2.00
Bicarbonate	211	189	183	217
Calcium	54	57	54	58
Chloride	19.2	19.1	19.0	19.9
Fluoride	0.22	0.21	0.23	0.24
Hardness, Total	304	328	308	322
Magnesium	41	45	42	43
Potassium	8	9	9	9
Sodium	67	76	71	73
Sulphate	248.1	241.9	251.8	261.2
Other				
Chlorophyll <i>a</i> (µg/L)	4.52	6.30	10.37	25.87
Conductivity (µg/L)	819	824	870	881
pH (pH units)	8.4	8.6	8.6	8.3
Turbidity (NTU)	2.23	1.66	3.30	10.00
Biochemical Oxygen Demand (mg/L)	<2.0	<2.0	<2.0	2.6
Chemical Oxygen Demand (mg/L)	19.1	20.3	18.5	18.4

Table 18: Shoreline Station – Shields 2007 Surface Parameters

Blackstrap Lake Shoreline Station - North 2007 Surface Parameters	
	October 17
Nutrients (mg/L)	
Dissolved Organic Carbon	8.1
Nitrate, as Nitrogen	<0.04
Ammonia, as Nitrogen	<0.02
Total Kjeldahl Nitrogen	0.8
Total Phosphorous	0.06
Ortho-Phosphate, as P	0.03
Solids (mg/L)	
Dissolved, Total	685
Suspended, Fixed	2
Suspended, Volatile	9
Suspended, Total	11
Bacteria (orgs/100 mL)	
E. Coli	41
Total Coliform	309
Major Ions (mg/L)	
Alkalinity, Total	180
Alkalinity, Phenol	2.00
Bicarbonate	215
Calcium	57
Chloride	20.1
Fluoride	0.23
Hardness, Total	324
Magnesium	44
Potassium	9
Sodium	73
Sulphate	265.3
Other	
Chlorophyll <i>a</i> (µg/L)	9.98
Conductivity (µg/L)	879
pH (pH units)	8.3
Turbidity (NTU)	7.9
Biochemical Oxygen Demand (mg/L)	<2
Chemical Oxygen Demand (mg/L)	26.4

Table 19: Shoreline Station – North 2007 Surface Parameters

Blackstrap Lake Shoreline Station - Thode 2007 Surface Parameters				
	June 27	July 30	Sept 4	Oct 4
Nutrients (mg/L)				
Dissolved Organic Carbon	14.8	8.4	7.9	7.7
Nitrate, as Nitrogen	<0.04	<0.04	0.07	0.13
Ammonia, as Nitrogen	0.02	<0.02	0.04	0.02
Total Kjeldahl Nitrogen	0.7	0.7	0.8	1.1
Total Phosphorous	<0.02	0.07	0.07	0.06
Ortho-Phosphate, as P	0.03	0.05	0.05	0.05
Solids (mg/L)				
Dissolved, Total	553	552	549	580
Suspended, Fixed	1	9	1	2
Suspended, Volatile	2	4	3	5
Suspended, Total	3	13	4	7
Bacteria (orgs/100 mL)				
E. Coli	<10	52	1	<10
Total Coliform	<10	3,448	166	41
Major Ions (mg/L)				
Alkalinity, Total	169	168	165	169
Alkalinity, Phenol	6.11	5.00	0.00	0.00
Bicarbonate	191	193	201	206
Calcium	53	57	52	56
Chloride	13.5	13.3	13.2	14.3
Fluoride	0.20	0.20	0.21	0.21
Hardness, Total	264	286	262	280
Magnesium	32	35	32	34
Potassium	8	9	8	8
Sodium	50	56	51	54
Sulphate	198.2	182.6	191.7	207.1
Other				
Chlorophyll <i>a</i> (µg/L)	8.52	8.52	11.48	10.77
Conductivity (µg/L)	698	700	725	745
pH (pH units)	8.5	8.4	8.3	8.2
Turbidity (NTU)	2.96	8.79	3.20	3.10
Biochemical Oxygen Demand (mg/L)	<2.0	<2.0	<2.0	3.9
Chemical Oxygen Demand (mg/L)	20.1	18.8	12.5	20.7

Table 20: Shoreline Station - Thode 2007 Surface Parameters